View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Okayama University Scientific Achievement Repository

Acta Medica Okayama

Volume 24, *Issue* 3 1970 *Article* 8

JUNE 1970

Forecasting median and mode dates of prevalence of Japanese encephalitis patients by electronic computer (epidemiological studies on Japanese encephalitis, 31)

Masana Ogata* Hirokazu Osaki†

*Okayama University,
†Okayama University,

Copyright ©1999 OKAYAMA UNIVERSITY MEDICAL SCHOOL. All rights reserved.

Forecasting median and mode dates of prevalence of Japanese encephalitis patients by electronic computer (epidemiological studies on Japanese encephalitis, 31)*

Masana Ogata and Hirokazu Osaki

Abstract

For the purpose of forecasting the prevalence ofJapanese encephalitis in Japan, we tried to find out the correlation of factors between median and mode dates of epidemic time curve of prevalence on one hand, and average atmospheric temperatures of prefectures in June and July (T6,7 in short) (X^1), the time when HI reaction of swine became positive to the degree of 50 per cent (D. pos. swine in short) (X^2), the latitude (x^3) and longitude (x4) in respective prefectures (in 1965 and 1967). On the other we also estimated the median and mode dates of this epidemic curve of the prevalence in 1968 and 1969, from the regression equation of one variable and multiple regression equation from the above factors using an electronic computer. The usefulness of adding factors concerned with mosquitoes to the above four factors is proven by the accuracy of estimation. And the following results were obtained. 1) Phenomenally speaking, the prevalence of Japanese encephalitis follows the principle of "advancing of prevalence towards the north and east" and essentially speaking, it depends upon high atmospheric temperature and the outbreak of many hazardous mosquitoes by the high atmospheric temperature. 2) To estimate median date (y) and mode rate (z) of the epidemic time curve of the prevalence, we can use the next equations; The regression equations to estimate y and z from T 6,7(X) are as follows. y = - 3. 75X^1 + 144.47 σ = 12.4.·. [1] z = - 3. 80X^1 + 157 .26 σ = 14.9.. · [1]' The regression equation from D. pos. swine (X^2) are as follows. y = 0. 68X^2 + 31. 82 σ = 9.2· .. [2] z=0. 76X^2 +40. 71 σ= 12.0 .. · [2]' The multiple regression equation from T6 ,7 and D. pos. swme are as follows. y = -1. 07X^1 +0 .62x^2 +59. 37 σ= 9.7 ... [3] z= -0. 79x^1 +0. 71x^2 +61.02 σ= 12.0· .. [3]' The multiple regression equations from T 6•7, D. pos. swine, latitude and longitude are as follows Y= -1.01x^1 +0.58x^2 -0.26x^3+0 .37x4 + 18.50 σ= 9.8･･･ [4] z = -0. 32x^1 +0. 52x^2 +2 .05x^3 +0 .54x4 -87. 81 σ= 11.8 [4]' 3) We Obtained the estimated value of median date in 17 prefectures in Kyushu, Chugoku, Shikoku, Kinki and Kanto provinces in 1968 and in 13 prefectures in 1969 from [l] or [2] or [3] or [4] equation. Nine prefectures out of 17 by [l], 12 prefectures by [2], 13 by [3J and [4] in 1968. [4] could be estimated with about 10 days error or less. And in 1969, 9 out of 13 by [3] and 7 out of 13 by [4] could be accurately esti· mated. The estimation by

*PMID: 4395193 [PubMed - indexed for MEDLINE] Copyright ©OKAYAMA UNIVERSITY MEDICAL SCHOOL

the multiple regression equation using many factors is most useful for the calculation. 4) The time when the number of patients increases at maximum can be pointed out by the lower limit of prediction region obtained from data in each prefecture. And the lower limit was the estimated median value minus about 20 days by [1] and about 16 days by [2] or [3] or [4] under the next condition; α = 0. 1, N= 75. 5) The mode dates in 17 prefectures out of 19 were estimated by [1]', [2]', [3]' and [4]'. 12 prefectures out of 17 by [1]', 7 by [2]', 10 by [3]' and 13 by [4]' could be estimated with about 12 days error or less in 1968 and 9 out of 13 was correctly estimated by [3]' and [4]' in 1969. The estimation by the regression line of one factor was s∼mewhat different from each other, but when multiple regression line of four factors was used the estimation became more correct. Judging from these results, it is adequate to use the multiple regression equation of [4] and [4]' when we want to forecast the median date or mode date ofJapanese encephalitis time cure. 6) In the case of adding two factors concerned with mosquitoes to T6,7 (X^1), D. pos. swine (x^2), latitude (x^3), longitude (x4), multiple regression equations become as follows. y= -1.46x^1+0.14X^2+0.068x5+89.03 σ= 6.9.. ·[5] z= -3. 29x^1+0 .13x^2-0. 010x5+ 143.63 σ= 18.6··· [5]' y=-4.20x^1+0.35x^2+0.29x6 + 53.70 σ= 4.2 .. ·[6] z=-2.56x^1-0.0lx^2-0.02x6 +128.96 σ=11.4 [6]' y= 4.76x^1+0.41x^2+0.13x5+0.22x6-72.78 σ= 4.5 [7] z = - 2. l0x^1 + 0. 05x^2+ 0. 11 x5 - 0. 08x6+ 113.4 σ= 10. 7.. · [7]' where x5 is the time when the number of mosquitoes (C. T. collected by light trap reached the maximum and X6 is the time when hazardous mosq uitoes were dected. In the case of median date, 5 prefectures out of 6 prefectures by [5], 2 out of 6 by [6] and 2 out of 5 by [7], and in the case of mode date, 5 out of 6 by [5]', 4 out of 5 by [6]' and 4 out of 5 by [7]' could be accurately estimated in 1969.

Acta Med. Okayama **24**, 343—353 (1970)

FORECASTING MEDIAN AND MODE DATES OF PREVALENCE OF JAPANESE ENCEPHALITIS PATIENTS BY ELECTRONIC COMPUTER (EPIDEMIOLOGICAL STUDIES ON JAPANESE ENCEPHALITIS, 31)

Masana OGATA* and Hirokazu OSAKI**

**Department of Public Health, Okayama University Medical School, Okayama, Japan*
***Department of Industrial Engineering, Okayama University*
(Director: Prof. M. Ogata)

Received for publication, March 10, 1970

As to the route of the infection of Japanese encephalitis virus, it is thought that the virus propagates in amplifiers of swine (1) and herons (2), and mosquitoes, which bite swine and herons during viremia, change themselves into hazardous mosquitoes. In order to estimate the time course of epidemic curve of Japanese encephalitis patients, the onset time of hazardous mosquitoes is most important. And this time has a close correlation to atmospheric temperature in summer, what we call "onset by high atmospheric temperature (3—8). On the other hand, the time when HI reaction of swine becomes positive to the degree of 50 per cent (D. pos. swine in short) is also necessary for determining the onset of hazardous mosquitoes, as there is a close correlation between D. pos. swine and median date or mode of epidemic time curve (3—8).

In the present study we attempted to predict the median and mode dates of epidemic time curve of Japanese encephalitis patients from the average atmospheric temperature of June and July (T 6, 7 in short), D. pos. swine, latitude and longitude. For this purpose the multiple regression equation of the median date or mode date from the above four components was formulated from data of prefectures in Japan in 1965, 1966 and 1967 using an electronic computer, and comparison was made between the observed values and the predicted values in 1968 and 1969. In addition, we attempted to estimate median and mode dates with factors made up of the factors concerned whit mosquitoes plus the four factors.

MATERIALS AND METHODS

Regression line of one dimension ;

This method is used for estimating the median date of epidemic time curve of prevalence by some designated factor out of various factors.

Multipleregression line ;

By the previous method, regression lines by each factor are calculated, but such a method does not make it clear which regression line is used in the estimation. Therefore, in this paper it must be made clear first that the median date of epidemic time curve of prevalence is estimated by the multipleregression line which is calculated by several factors and its prediction region. These calculations are conducted by NEAC 2203, and HITAC 5020E at the Electronic Computer Center of Tokyo University.

Multpleregression equation calculated is as follows :

y = median date of epidemic time curve of prevalence

$x = (x_1, x_2, \cdots x_k)$: variable of k dimension

$x_i = (x_{i1}, x_{i2}, \cdots x_{ik})$: observation of x

$i = 1, 2, \cdots, N$

Regression line

$$\hat{y} = \bar{y} + \sum_{i=1}^{k} \beta_i (x_i - \bar{x}_i)$$

where, $\bar{x}_i = \frac{1}{N} \sum_{j=1}^{N} x_{ij} \qquad i = 1, 2, \cdots\cdots, k$

β_i : regression coefficients $\quad j = 1, 2, \cdots\cdots, k$

$S = (\sum_{l=1}^{N} (x_{li} - \bar{x}_i)(x_{lj} - \bar{x}_j))$, $k \times k$ variance - convariance matrix

$d = (\sum_{l=1}^{N} (x_{l1} - \bar{x}_1)(y_l - \bar{y}), \cdots\cdots, \sum_{l=1}^{N} (x_{lk} - x_k)(y_l - \bar{y}))'$

: $1 \times k$ vector

then $(\beta_1, \beta_2, \cdots\cdots, \beta_k) = d' \cdot S^{-1}$

For any $x_0 = (x^0{}_1 \cdots\cdots, x^0{}_k)$, the prediction region of the median date of epidemic time curve of patient is calculated by the next equation.

$$\hat{y}_0 - t_\alpha(N-k-1)\,\sigma\sigma_0 \leq y \leq \hat{y}_0 + t_\alpha(N-k-1)\,\sigma\sigma_0$$

where

$\hat{y}_0 = \bar{y} + \sum \beta_i (x^0{}_i - \bar{x}_i)$

$\sigma^2 = d' S^{-1} d / N-k-1$; deviation from the regression

$$\sigma_0{}^2 = (1, x^0{}_1, \cdots x^0{}_k) \begin{pmatrix} N & \sum x_{j1} \cdots\cdots & \sum x_{jk} \\ \sum x_{j1} & \sum x_{j1}^2 \cdots & \sum x_{j1} x_{jk} \\ \vdots & \vdots & \vdots \\ \sum x_{jk} & \sum x_{j1} x_{jk} \cdots & \sum x_{jk}^2 \end{pmatrix}^{-1} \begin{pmatrix} 1 \\ x_0^1 \\ \vdots \\ x_k^0 \end{pmatrix}$$

$t_\alpha (N-k-1)$ = value of t distribution level α, $d.f = N-k-1$

RESULTS

1. *Correlation among various factors*

The correlation coefficient between the median date of epidemic time curve of Japanese encephalitis and latitude was 0.58 and that between the mode date and latitude was 0.63 as shown in Table 1. Further, that between median date or mode date and longitude was 0.57 or 0.60. In this case median date and mode were counted from 20th of June in the preceding calculation. This shows that Japanese encephalitis prevails toward the northeast.

TABLE 1. MEAN VALUE AND VARIANCE OF EACH FACTOR AND CORRELATION COEFFICIENT AMONG VARIOUS FACTORS CALCULATED BY DATA OBTAINED 75 (MEDIAN) AND 74 (MODE) PREFECTURES IN JAPAN IN 1965, 1966 AND 1967. (THE DATA ARE USED FOR CALCULATION OF MEDIAN AND THAT IN PARENTHESIS ARE USED FOR CALCULATION OF MODE.)

	$T_{6,7}$	S_{50}	Lat.	Long.	Pmd	Pmo
$T_{6,7}$	1	−0.53 (−0.53)	−0.54 (−0.54)	−0.49 (−0.48)	−0.48	−0.42
S_{50}		1	0.76 (0.75)	0.73 (0.72)	0.72	0.68
Lat.			1	*	0.58	0.63
1 ong.				1	0.57	0.60
Mean	23.6 (23.5)	35.2 (35.6)	34.7 (34.8)	135.3 (135.3)	56.0	67.8
Unbiased variance	3.31 (3.33)	223.39 (217.62)	2.17 (2.06)	10.79 (10.73)	201.41	271.87

$T_{6,7}$: average atmospheric temperatures of prefectures in June and July
S_{50} : time when HI reaction of swine became positive by degree of 50 per cent
Lat. : latitude Long.; longitude
Pmd : median date of this epidemic curve of the prevalence
Pmo : mode date of this epidemic curve of the prevalence

The correlation coefficient between median date or mode date and average atmospheric temperature in June and July was −0.48 or −0.42. That is, the higher the average atmospheric temperature, the earlier are the median date and mode date. This shows the tendency of "onset by high atmospheric temperature". The correlation coefficient between average atmospheric temperature of June and July (T 6, 7 in short) and the date when HI reaction of swine became positive to the degree of 50 per cent (D. pos. swine in short) was −0.53, then the higher the T 6, 7 is, the earlier the date of D. pos. swine. Further, that between median date or mode date and the date of D. pos. swine was 0.72 or 0.68. And median date and mode date were closely correlated with the date of D. pos. swine.

2. *Estimation of median and mode dates of epidemic time curve of patients*

i) Estimation from $T_{6,7}$, *D.* pos. swine, latitude and longitude

Median and mode date are calculated from four factors by various regressions. The following notations were used for four factors.

x_1 : average atmospheric temperature in prefecture in June and July ($T_{6,7}$)

x_2 : the date when HI reaction of swine became positive to the degree of 50 per cent (*D.* po. swine)
x_3 : latitude
x_4 : longitude
y : median date
z : mode date

a) Regression equations of median date (y) and mode date (z) from only $T_{6,7}$ (x_1) are shown as follows.

$y=-3.75x_1+144.47$ $\sigma=12.4\cdots[1]$

$z=-3.80x_1+157.26$ $\sigma=14.9\cdots[1]'$

where σ is standard deviation from regression line.

b) Regression equations of median date (y) and mode (z) from only *D.* pos. swine (x_2) are shown as follows.

$y=0.68x_2+31.82$ $\sigma=9.2\cdots[2]$

$z=0.76x_2+40.71$ $\sigma=12.0\cdots[2]'$

c) The multipleregression equations from $T_{6,7}(x_1)$ and *D.* pos. swine (x_2) are shown as follows.

$y=-1.07x_1+0.62x_2+59.37$ $\sigma=9.7\cdots[3]$

$z=-0.79x_1+0.71x_2+61.02$ $\sigma=12.0\cdots[3]'$

d) The multipleregression equations from $T_{6,7}(x_1)$, *D.* pos. swine (x_2), latitude (x_3) and longitude (x_4) as follows.

$y=-1.01x_1+0.58x_2-0.26x_3+0.37x_4+18.50$ $\sigma=9.8\cdots[4]$

$z=-0.32x_1+0.52x_2+2.05x_3+0.54x_4-87.81$ $\sigma=11.8\cdots[4]'$

Table 2 shows the observed median date and the estimated values of median date from [1], [2], [3] and [4] equations. The standard deviations from regression lines of median date were about 9~12 days. Therefore, if it is to be admitted that the difference between the observed value and the estimated value was less than 10 days, 9 out of 17 prefectures by equation [1] and 12 out of 17 by the others could be accurately estimated within admissible difference, and four prefectures, where the observed value of median date could not be correctly estimated by [2], could not be estimated by [3] and [4] in 1968 either. The prefectures in Kyushu and Chugoku provinces were (almost all) accurately estimated by the regression line of [2], [3] and [4]. And in 1969, 9 prefectures out of 13 by [3], 7 out of 13 by [4] could be estimated.

Further, the median date was also estimated by the prediction region from regression line. For example, the interval of the prediction region in mean value of each factor was equal to that of the value of $\sigma\cdot t_a(\mathrm{N}-\mathrm{k}-1)$. In equation [1] and [2], $t_{1.0}(75-1-1)\cdot\sigma$ are $1.668\times12.4=20.68$ in [1] and $1.668\times9.7=16.17$. And in [3] and [4], those are $t_{0.1}(75-1-2)\cdot\times$

TABLE 2. FOUR FACTORS ($T_{6,7}$, D. POS. SWINE, LATITUDE AND LONGITUDE) IN EACH PREFECTURE IN 1968 AND 1969, MEDIAN AND MODE OF THE PREVALENCE OF JAPANESE ENCEPHALITIS AND MEDIAN AND MODE DATE ESTIMATED FROM EQUATION [1] OR [2] OR [3] OR [4] AND [1]′ OR [2]′ OR [3]′ OR [4]′

Prefecture	1968 Factors				1968 Median Act.	1968 Median Estimated				1968 Mode Act.	1968 Mode Estimated				1969 Factors		1969 Median Act.	1969 Median Estimated		1969 Mode Act.	1969 Mode Estimated	
	$T_{6,7}$	S 50	Lat.	Long.	Pmd	by [1]	by [2]	by [3]	by [4]	Pmo	by [1]′	by [2]′	by [3]′	by [4]′	$T_{6,7}$	S50	Pmd	by [3]	by [4]	Pmo	by [3]′	by [4]′
Kumamoto	24.2	30	32.7	130.6	60	54	52	52	51	51	65	64	63	58	24.5	38	52	57	57	60	69	61
Miyazaki	23.5	24	31.9	131.5	44	56	48	49	49	46	68	59	60	58	24.5	37						
Oita	22.8	38	33.2	131.5	49	59	58	59	57	40	71	70	70	64	23.4	24	64	49	49	74	60	56
Nagasaki	23.2	35	32.7	129.8	80	57	56	56	55	72	69	67	68	60	24.1	51	74	65	63	81	78	67
Saga	23.5	51	33.3	130.3	62	54	69	65	63	59	65	80	78	70	24.4	55						
Fukuoka	24.0	57	33.6	130.3	67	54	71	69	67	67	66	84	83	73	24.0	50	74	65	63	81	78	69
Ehime	23.9	36	33.8	132.7	69	56	57	57	56	67	68	68	68	64	23.5	37	64	70	68	74	83	74
Tokushima	23.3	55	34.1	134.5	76	55	70	68	67	80	69	83	81	75	23.4	36						
Koochi	23.3	32	33.5	133.5	65	55	54	54	53	65	66	65	65	62	23.8	39	67	58	58	88	70	65
Yamaguchi	23.2	40	34.3	135.2	66	57	59	59	59	70	69	71	71	69	23.0	31	67	54	53	88	65	62
Hiroshima	23.3	49	34.4	132.4	62	57	65	65	63	64	69	78	78	72	22.9	77	58	83	80	81	98	85
Shimane	23.2	51	35.5	133.1	70	57	67	66	64	80	67	86	84	78	22.5	55						
Okayama	23.7	62	34.6	133.9	71	55	72	71	69	75	67	86	84	88	22.9	53	63	68	67	71	81	75
Hyogo	24.8	59	34.7	134.8	64	51	72	69	68	71	63	86	83	79	23.0	41	58	60	60	67	72	69
Osaka	24.8	64	34.6	135.5	59	51	76	72	72	64	63	89	87	81	24.1	48	78	63	63	81	76	73
Wakayama	24.8	42	34.3	135.2	57	53	69	59	59	60	63	73	71	69								
Mie	23.5	39	34.6	136.5	50	56	59	58	59	50	68	70	70	70								
Kagoshima			31.5	131.5											24.7	33	51	53	53	53	65	56
Kyoto			35.0	135.8											23.8		71	61	61	81	73	71
Coincident ratio						9/17	12/17	13/17	13/17		12/17	7/17	10/17	13/17				9/13	7/13		9/13	9/13
Coincident per cent						53	71	76	76		71	41	60	76				69	54		69	69

Act. : Actual value $T_{6,7}$: average atmospheric temperatures of prefectures in June and July

S 50 : time when HI reaction of swine positive in degree of 50 per cent Lat. : Latitude Long. : Longitude

Pmd : median date of this epidemic curve of the prevalence Pmo : mode date of this epidemic curve of the prevalence

$9.7=16.18$ and $t_{0.1}(75-4-1)\times 9.8=16.42$, where $\alpha=0.1$ and $N=75$.

Table 2 also shows the observed mode date and the values estimed from [1]′, [2]′, [3]′ and [4]′. The standard deviations from the regression line of mode date were about 12∼15 days. These are greater than those of median date. If the admissible difference is by 12 days, 12 prefectures out of 17 by [1]′, 7 out of 17 by [2]′, 10 out of 17 by [3]′, and 13 out of 17 by [4]′ were accurately estimated within the admissible difference in 1968. The factor of *D.* pos. swine was most closely correlated with the mode date from 1965 to 1967, but not in 1968. So the mode date could not be estimated so accurately from [2]′ and [3]′. When the equation [4]′ was used, difference of each factor in each year was annulled and the mode date was quite accurately estimated. And in 1969, 9 prefectures out of 13 prefectures could be estimated by [3]′ and [4]′.

It can be said from these results that when multipleregression lines of [3], [3]′, [4] and [4]′ are used, the median date and the mode date can be accurately estimated within a given admissible difference.

ii) Estimation from factors made up of those factors concerned with mosquitoes plus four factors

We estimated median date or mode date with these integrated factors made up of adding to the above components (x_1 x_2 x_3 x_4), the two new components of date (x_5) when number of mosquitoes [Culex tritaeniorhynchus, C. t. in short] collected by light trap reached the maximum, and date (x_6) when hazardous mosquitoes were detected.

In these instances, the multiple regression equations were as follows.

$$y=-1.46x_1+0.14x_2+0.068x_5+89.03 \qquad \sigma=6.9\cdots[5]$$
$$z=-3.29x_1+0.13x_2-0.010x_5+143.63 \qquad \sigma=18.6\cdots[5]'$$
$$y=-4.20x_1+0.35x_2+0.29x^6+53.70 \qquad \sigma=4.2\cdots[6]$$
$$z=-2.56x_1-0.01x_2-0.02x_6+128.96 \qquad \sigma=11.4\cdots[6]'$$
$$y=4.76x_1+0.41x_2+0.13x_5+0.22x_6-72.78 \qquad \sigma=4.5\cdots[7]$$
$$z=-2.10x_1+0.05x_2+0.11x_5-0.08x_6+113.40 \qquad \sigma=10.7\cdots[7]'$$

In the case of median date, 5 prefectures out of 6 prefectures by equation [5], 2 out of 5 by [6], and 2 out of 5 by [7] could be accurately estimated. And in the case of mode date, 5 out of 6 by [5]′, 4 out of 5 by [6]′, and 4 out of 5 by [7]′ could be estimated. On the other hand, in median date, 3 prefectures out of 6 prefectures by equation [3] using only $T_{6,7}$ and *D.* pos. swine as factor, and in mode date 3 out of 6 by [3]′ could be accurately estimated. And 3 out of 6 by [4] and 4 out of 6 by [4]′ could be estimated. Therefore, accuracy of estimation did not increase so appreciably by the addition of the factors concerned with mosquitoes, though a little more accurate estimation could be attained by

TABLE 3. FACTORS ($T_{6,7}$, S_{50}, SWINE AND FACTORS CONCERNED WITH MOSQUITOES) IN EACH PREFECTURE IN 1968, MEDIAN AND MODE OF THE PREVALENCE OF JAPANESE ENCEPHALITIS AND MEDIAN AND MODE ESTIMATED FROM EQUATION [3] OR [5] OR [6] OR [7] AND [3]′ OR [5]′ OR [6]′ OR [7]′ IN 1968

Prefecture	Factors				Median						Mode					
						Estimated						Estimated				
	$T_{6,7}$	S_{50}	Mos.	H. Mos.	Act.	by[3]	by[4]	by[5]	by[6]	by[7]	Act.	by[3]′	by[4]′	by[5]′	by[6]′	by[7]′
Nagasaki	23.2	35	40	28	71	56	55	63	64	69	72	68	60	72	69	70
Fukuoka	24.0	57	43	49	67	69	67	65	81	81	67	83	73	72	66	67
Ehime	23.9	36	6	—	69	57	56	60	—	—	67	68	64	71	—	—
Hyogo	24.8	59	32	46	64	69	68	63	84	84	71	83	79	70	64	64
Osaka	24.8	64	41	55	59	72	72	64	88	89	64	87	81	70	64	65
Mie	23.5	39	27	5	50	58	59	62	60	60	50	70	70	71	69	69
Coincident ratio						3/6	3/6	5/6	2/5	2/5		3/6	4/6	5/6	4/5	4/5
Coincident %						50	50	83	40	40		50	67	83	80	80

$T_{6,7}$: average atmospheric temperatures of prefectures in June and July

S_{50} : time when HI reaction of swine became posivive in degree of 50 per cent

Mos. : time when the number of mosquitoes (C. t.) collected reached maximum

H. Mos. : time when hazardous mosquitoes were detected the addition of the date when number of mosquitoes (C. t.) collected by light trap reached maximum, to $T_{6,7}$ and *D.* pos. swine as factors of multiple regression equation. The accuracy of estimation was obtained from the results of the comparison between the actual and the estimated values in 1969.

DISCUSSION

As to the reason why the time when HI reaction of swine becomes positive to the degree of 50 per cent (*D.* pos. swine) enables us to estimate the median date of epidemic time curve of the Japanese encephalitis patient, may be explained as follows. About five days after the time when swine is bitten by hazardous mosquitoes, viremia is detected in the swine. And 14 days after non-hazardous mosquitoes suck the blood of swine in the stage of viremia, these mosquitoes become hazardous. And inhabitants in the region show the symptoms of Japanese encephalitis 3 days after they are bitten by hazardous mosquitoes. Therefore, it is calculated that patients with symptom are found 22 days after the time when hazardous mosquitoes have bitten the swine at first. As the HI reaction of swine is positive 14 days after hazardous mosquitoes bite the swine at first onset of patient is expected about 8 days after showing positive HI reaction of swine.

We have attempted to add factors concerned with mosquitoes to $T_{6,7}$ and *D.* pos. swine, latitude and longitude in multiple regression equation. However, the accuracy of the estimation turns out to be so beneficial by the addition of these factors, though the addition of the time when number of mosquitoes (C. t.), collected by light trap reaches the maximum, to $T_{6,7}$ and *D.* pos. swine as factors of multiple regression equation yields somewhat accurate estimation. This may be attributable to the smallness of number of prefectures, by which the multiple regression equation was made. And in this condition $T_{6,7}$ and *D.* pos. swine, latitude and longitude will be sufficient as factors for estimating the median and mode of epidemic time curves of Japanese encephalitis patients.

SUMMARY

For the purpose of forecasting the prevalence of Japanese encephalitis in Japan, we tried to find out the correlation of factors between median and mode dates of epidemic time curve of prevalence on one hand, and average atmospheric temperatures of prefectures in June and July ($T_{6,7}$ in

short) (x_1), the time when HI reaction of swine became positive to the degree of 50 per cent (*D.* pos. swine in short) (x_2), the latitude (x_3) and longitude (x_4) in respective prefectures (in 1965 and 1967). On the other we also estimated the median and mode dates of this epidemic curve of the prevalence in 1968 and 1969, from the regression equation of one variable and multiple regression equation from the above factors using an electronic computer. The usefulness of adding factors concerned with mosquitoes to the above four factors is proven by the accuracy of estimation.

And the following results were obtained.

1) Phenomenally speaking, the prevalence of Japanese encephalitis follows the principle of "advancing of prevalence towards the north and east" and essentially speaking, it depends upon high atmospheric temperature and the outbreak of many hazardous mosquitoes by the high atmospheric temperature.

2) To estimate median date (y) and mode rate (z) of the epidemic time curve of the prevalence, we can use the next equations;

The regression equations to estimate y and z from $T_{6,7}(x)$ are as follows.

$y=-3.75x_1+144.47$ $\qquad \sigma=12.4 \cdots [1]$

$z=-3.80x_1+157.26$ $\qquad \sigma=14.9 \cdots [1]'$

The regression equation from *D.* pos. swine (x_2) are as follows.

$y=0.68x_2+31.82$ $\qquad \sigma=\ 9.2 \cdots [2]$

$z=0.76x_2+40.71$ $\qquad \sigma=12.0 \cdots [2]'$

The multiple regression equation from $T_{6,7}$ and *D.* pos. swine are as follows.

$y=-1.07x_1+0.62x_2+59.37$ $\qquad \sigma=\ 9.7 \cdots [3]$

$z=-0.79x_1+0.71x_2+61.02$ $\qquad \sigma=12.0 \cdots [3]'$

The multiple regression equations from $T_{6,7}$, *D.* pos. swine, latitude and longitude are as follows

$y=-1.01x_1+0.58x_2-0.26x_3+0.37x_4+18.50$ $\qquad \sigma=\ 9.8 \cdots [4]$

$z=-0.32x_1+0.52x_2+2.05x_3+0.54x_4-87.81$ $\qquad \sigma=11.8 \cdots [4]'$

3) We obtained the estimated value of median date in 17 prefectures in Kyushu, Chugoku, Shikoku, Kinki and Kanto provinces in 1968 and in 13 prefectures in 1969 from [1] or [2] or [3] or [4] equation. Nine prefectures out of 17 by [1], 12 prefectures by [2], 13 by [3] and [4] in 1968. [4] could be estimated with about 10 days error or less. And in 1969, 9 out of 13 by [3] and 7 out of 13 by [4] could be accurately estimated. The estimation by the multiple regression equation using many factors is most useful for the calculation.

4) The time when the number of patients increases at maximum can

be pointed out by the lower limit of prediction region obtained from data in each prefecture. And the lower limit was the estimated median value minus about 20 days by [1] and about 16 days by [2] or [3] or [4] under the next condition ; $\alpha=0.1$, $N=75$.

5) The mode dates in 17 prefectures out of 19 were estimated by [1]′, [2]′, [3]′ and [4]′. 12 prefectures out of 17 by [1]′, 7 by [2]′, 10 by [3]′ and 13 by [4]′ could be estimated with about 12 days error or less in 1968 and 9 out of 13 was correctly estimated by [3]′ and [4]′ in 1969. The estimation by the regression line of one factor was somewhat different from each other, but when multiple regression line of four factors was used the estimation became more correct.

Judging from these results, it is adequate to use the multiple regression equation of [4] and [4]′ when we want to forecast the median date or mode date of Japanese encephalitis time cure.

6) In the case of adding two factors concerned with mosquitoes to $T_{6,7}$ (x_1), *D.* pos. swine (x_2), latitude (x_3), longitude (x_4), multiple regression equations become as follows.

$$y=-1.46x_1+0.14x_2+0.068x_5+89.03 \qquad \sigma=6.9\cdots[5]$$
$$z=-3.29x_1+0.13x_2-0.010x_5+143.63 \qquad \sigma=18.6\cdots[5]'$$
$$y=-4.20x_1+0.35x_2+0.29x_6+53.70 \qquad \sigma=4.2\cdots[6]$$
$$z=-2.56x_1-0.01x_2-0.02x_6+128.96 \qquad \sigma=11.4\cdots[6]'$$
$$y=4.76x_1+0.41x_2+0.13x_5+0.22x_6-72.78 \qquad \sigma=4.5\cdots[7]$$
$$z=-2.10x_1+0.05x_2+0.11x_5-0.08x_6+113.4 \qquad \sigma=10.7\cdots[7]'$$

where x_5 is the time when the number of mosquitoes (C. t.) collected by light trap reached the maximum and x_6 is the time when hazardous mosquitoes were dected.

In the case of median date, 5 prefectures out of 6 prefectures by [5], 2 out of 6 by [6] and 2 out of 5 by [7], and in the case of mode date, 5 out of 6 by [5]′, 4 out of 5 by [6]′ and 4 out of 5 by [7]′ could be accurately estimated in 1969.

ACKNOWLEDGEMENT

The authors wish to express profound gratitude to Dr. AKIRA OYA of Department of Virology & Rickettsiology, National Institute of Health (Japan) for kind aid in performing the present investigation.

This investigation was supported by research grants from the Japanese Ministry of Education.

REFERENCES

1. WILLIAM, F. SCHERER, *et al.*: Immunological studies of Japanese Encephalitis Virus in Japan, V. Maternal antibodies, antibody responses and viremia following infection of swine, *The Journal of Immunology* **83**, 620, 1959
2. EDWARD, L. BUESCHER, WILLIAM, F. SCHERER, *et al.*: Immunologic studies of Japanese encephalitis virus in Japan, IV. Maternal antibody in birds. *The Journal of Immunology* **83**, 614, 1959
3. OGATA, M. and OSAKI, H.: Phenomenon of "Tendency of prevalence of Japanese encephalitis in Japan toward the northeast", "Onset by high temperature" and forecasting its prevalence by atmospheric temperature and HI reaction of swine, *Okayama-Igakkai-Zasshi* **80**, 1—2, Supplement X, 1968 (in Japanese)
4. OGATA, M. and OSAKI, H.: Forecasts of prevalence of Japanese encephalitis and "Advancing of prevalence in Japan toward the northeast" and "Onset by high atmospheric temperature" *Japanese Journal of Public Health* **16**, 6, 587, 1969 (in Japanese)
5. OGATA, M. and OSAKI, H.: On forecasting prevalence of Japanese encephalitis in Japan, estimation of median date of prevalence in 1968 from the date of 1965 to 1967 *Okayama-Igakkai-Zasshi* **81**, 1—2, Supplement XI, 1969 (in Japanese)
6. OGATA, M. and OSAKI, H.: On forecasting prevalence of Japanese encephalitis in Japan, estimation of mode *Okayama-Igakkai-Zasshi* **81**, 1—2, Supplement XI, 1969 (in Japanese)
7. OGATA, M. and OSAKI, H.: Forecasts on date of prevalence of Japanese encephalitis (Epidemiological study on Japanese encephalitis) *Okayama-Igakkai-Zasshi* Supplement XII, 1970 (in Japanese)
8. OGATA, M. and OSAKI, H.: Forecasts on degree of prevalence of Japanese encephalitis and period of cycle of incidence in various prefectures of Japan, *Okayama-Igakkai-Zasshi*, Supplement XII, 1970 (in Japanese)
9. OYA, A.: Survey of appearance of Culex tritaeniorhynchus and forecasting of prevalence of Japanese encephalitis from hazardous mosquitoes, Research Meeting of Ecology of Japanese Encephalitis Nihon-noen Virus Seitai Kenkyukai (Abstracts), 1969 (in Japanese)